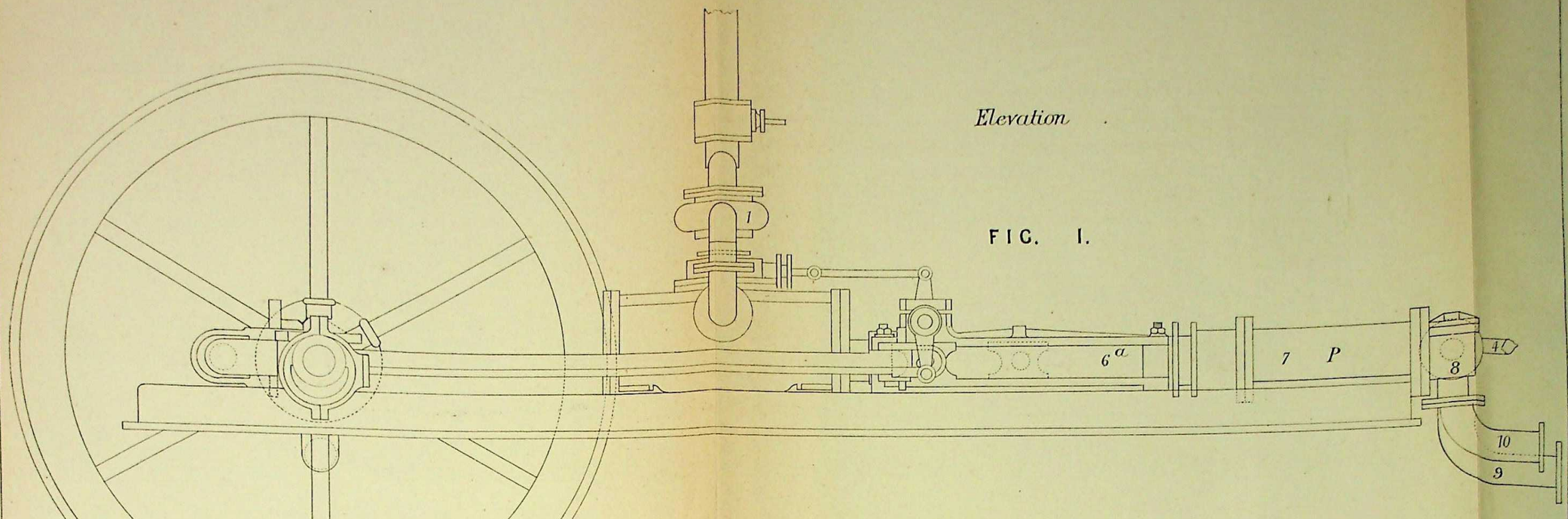
A.D. 1868. Oct. 26. N°. 3278.
MORT'S Complete Specification.

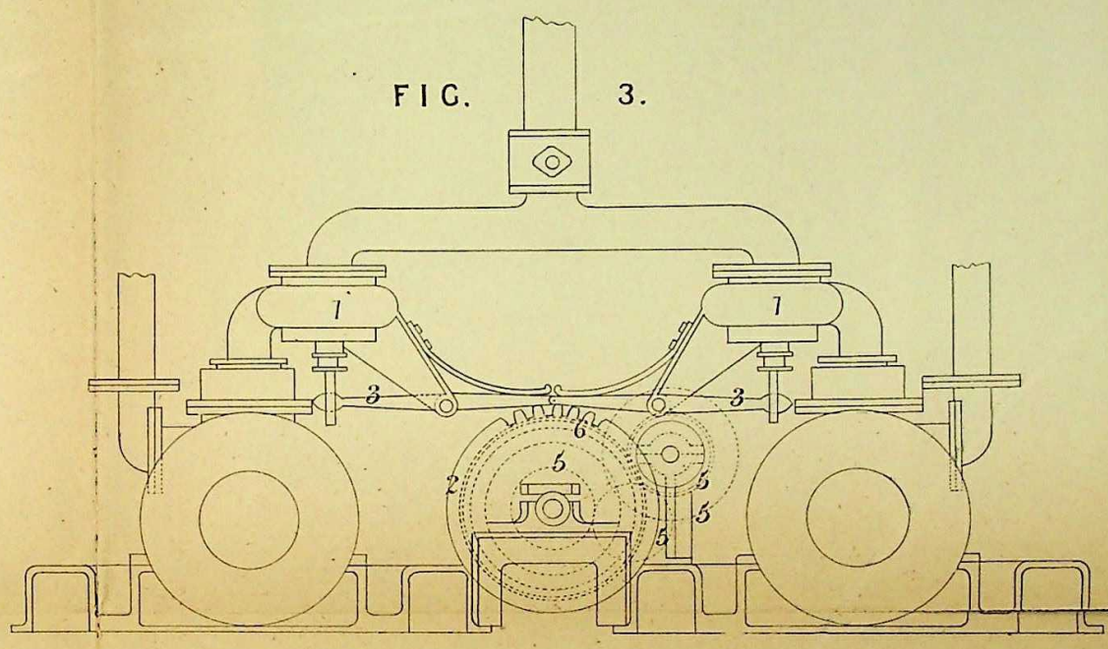
(5 SHEETS)
SHEET 1.

DRAWING N° 1.



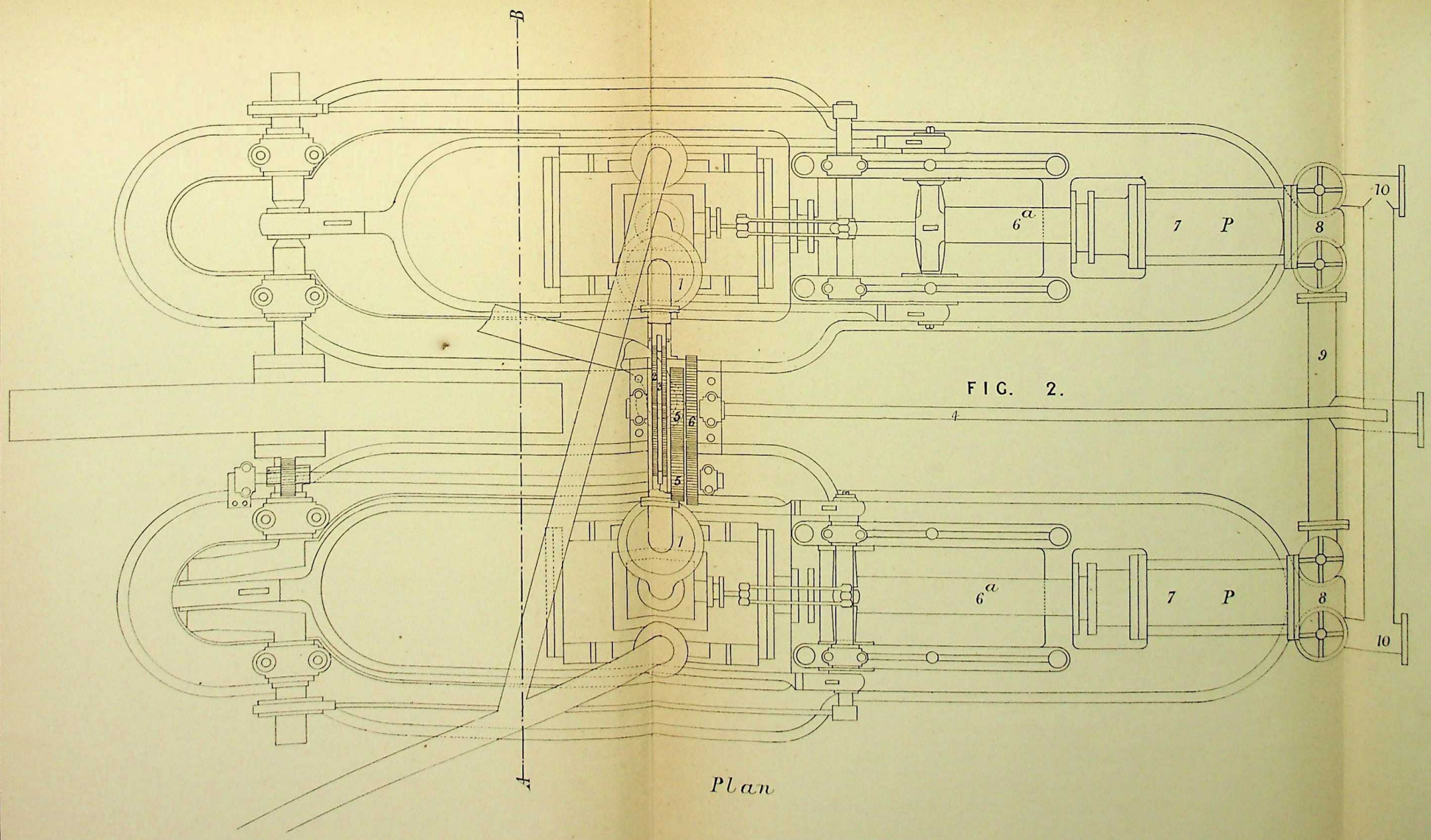
Elevation

FIG. 1.



Transverse Section at A. B

FIG. 3.



Plan

FIG. 2.

The filed drawing is not colored.

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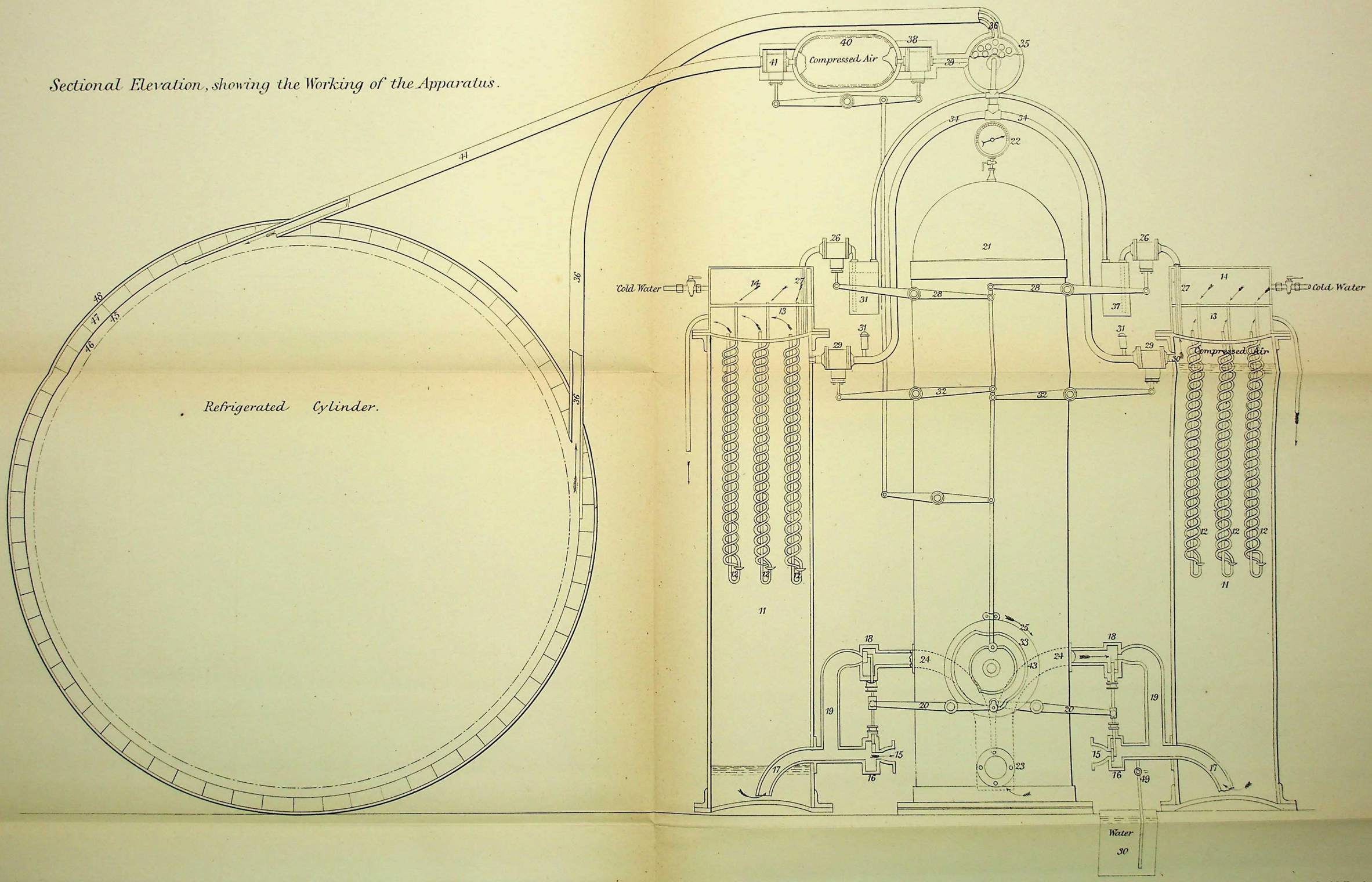
Sectional Elevation, showing the Working of the Apparatus.



The filed drawing is partly colored.

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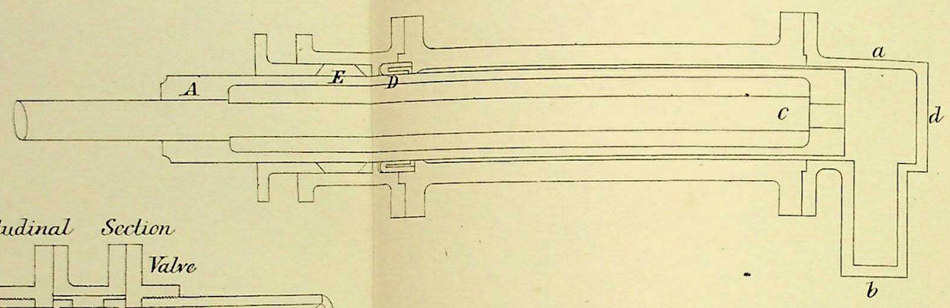
Longitudinal Section

FIG. 1.



Longitudinal Section
Air Valve

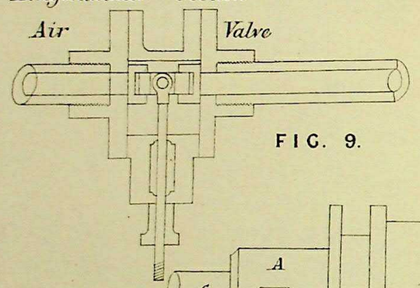
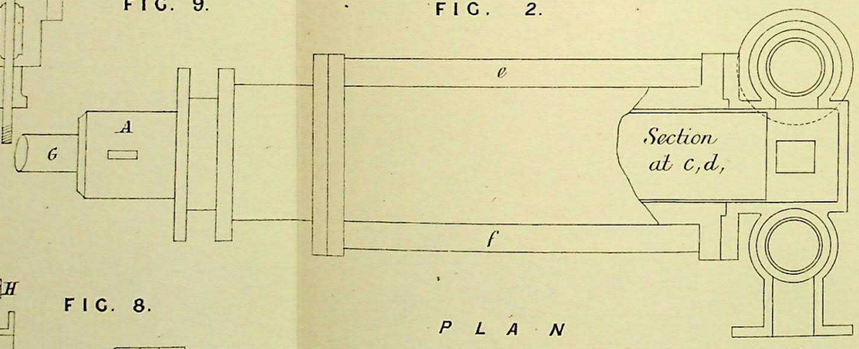


FIG. 9.

Pump

FIG. 2.



PLAN

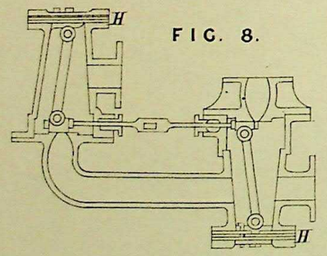


FIG. 8.

Section of Equilibrium Valve

Transverse Section at a, b,

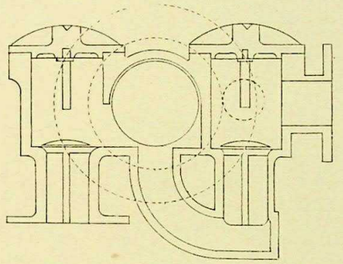


FIG. 3.

Section at e, f.

FIG. 4.

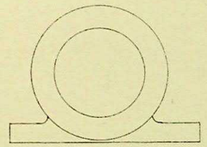
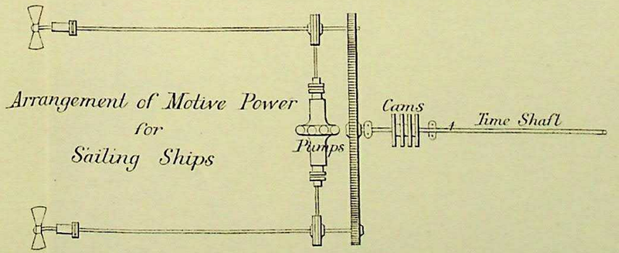


FIG. 10.



Section at a, b,

FIG. 6.

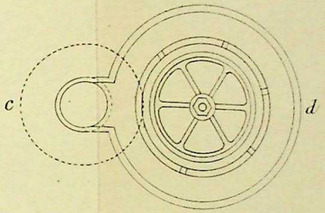
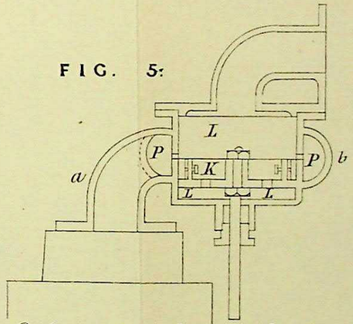


FIG. 5.



Section at c, d,

EXPANSION VALVE

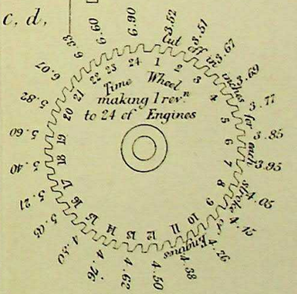


FIG. 7.

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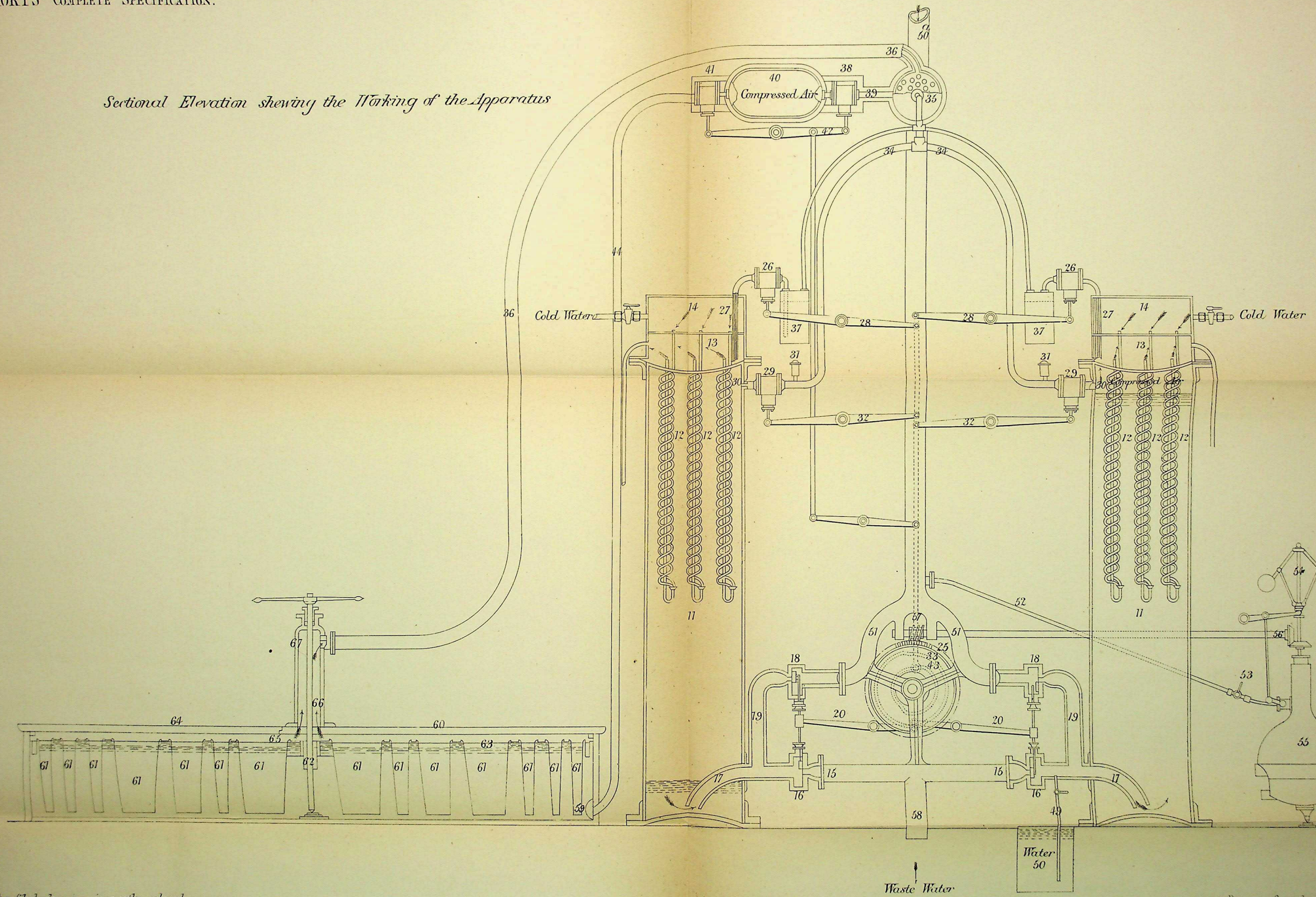
DRAWING N° 4.

Sectional Elevation shewing the Working of the Apparatus



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DRAWING N° 5.

TIME WHEEL TABLE

Air compressed from pressure of 10 Atmos to that of 20 Atmos by 48 Strokes of the Pump.		Power = 2 Steam Cyls 12in. diam. 24in. Str. Inl. pressure Steam = 60lbs. 12+in. at cut off.	
Mean Pressure of each stroke		Minimum Pressure.	
Stroke.	Atmos.	Inches.	Lbs.
1	10 · 05	3 · 50	17 · 0
2	10 · 15	3 · 52	17 · 2
3	10 · 26	3 · 54	17 · 4
4	10 · 37	3 · 57	17 · 6
5	10 · 48	3 · 59	17 · 8
6	10 · 60	3 · 62	18 · 0
7	10 · 72	3 · 65	18 · 2
8	10 · 84	3 · 69	18 · 4
9	10 · 96	3 · 73	18 · 6
10	11 · 08	3 · 77	18 · 8
11	11 · 20	3 · 81	19 · 0
12	11 · 33	3 · 85	19 · 3
13	11 · 47	3 · 90	19 · 5
14	11 · 61	3 · 95	19 · 7
15	11 · 75	4 · 00	19 · 9
16	11 · 90	4 · 05	20 · 2
17	12 · 06	4 · 10	20 · 4
18	12 · 22	4 · 15	20 · 7
19	12 · 38	4 · 21	21 · 0
20	12 · 54	4 · 26	21 · 3
21	12 · 70	4 · 32	21 · 6
22	12 · 87	4 · 38	21 · 9
23	13 · 05	4 · 44	22 · 2
24	13 · 23	4 · 50	22 · 5
25	13 · 41	4 · 56	22 · 8
26	13 · 60	4 · 62	23 · 1
27	13 · 80	4 · 69	23 · 4
28	14 · 00	4 · 76	23 · 8
29	14 · 21	4 · 83	24 · 1
30	14 · 43	4 · 90	24 · 5
31	14 · 65	4 · 97	24 · 9
32	14 · 87	5 · 05	25 · 3
33	15 · 10	5 · 13	25 · 7
34	15 · 34	5 · 21	26 · 1
35	15 · 59	5 · 30	26 · 5
36	15 · 85	5 · 40	26 · 9
37	16 · 12	5 · 50	27 · 4
38	16 · 40	5 · 60	27 · 9
39	16 · 69	5 · 71	28 · 4
40	16 · 99	5 · 82	28 · 9
41	17 · 30	5 · 94	29 · 5
42	17 · 62	6 · 07	30 · 0
43	17 · 94	6 · 20	30 · 5
44	18 · 28	6 · 33	31 · 1
45	18 · 62	6 · 46	31 · 6
46	18 · 99	6 · 60	32 · 3
47	19 · 38	6 · 75	32 · 9
48	19 · 79	6 · 90	33 · 6
Mean 13·85 Atmos = 3990 lbs on Pump at 96 revols of Engine per min = 46·4 H. P		Mean = 23·5 lbs = 5311 lbs on 2 Pistons at 96 revols of Engine per min = 61·8 I.H.P.	

The filed drawing is not colored.

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A.D. 1868, *26th October.* N° 3278.

Refrigerating, &c.

LETTERS PATENT to William Mort, of Fenchurch Street, in the City of London, for the Invention of "AN IMPROVED METHOD OF AND APPARATUS FOR OBTAINING REDUCTION OF TEMPERATURE BY THE EXPANSION OF AIR OR OTHER PERMANENT GASES IN SPECIAL CONNECTION WITH THE PRESERVATION OF ARTICLES OF FOOD, THE MANUFACTURE OF ICE, COOLING OF ROOMS AND LIQUIDS."—A communication from abroad by Thomas Sutcliffe Mort and Eugene Dominique Nicolle, of Sydney, in the Colony of New South Wales.

Sealed the 19th January 1869, and dated the 26th October 1868.

COMPLETE SPECIFICATION filed by the said William Mort at the Office of the Commissioners of Patents, with his Petition and Declaration, on the 26th October 1868, pursuant to the 9th Section of the Patent Law Amendment Act, 1852.

TO ALL TO WHOM THESE PRESENTS SHALL COME, I, WILLIAM MORT, of Fenchurch Street, in the City of London, do hereby declare the nature of the said Invention for "AN IMPROVED METHOD OF AND APPARATUS FOR OBTAINING REDUCTION OF TEMPERATURE BY THE EXPANSION OF AIR OR OTHER

PERMANENT GASES IN SPECIAL CONNECTION WITH THE PRESERVATION OF ARTICLES OF FOOD, THE MANUFACTURE OF ICE, COOLING OF ROOMS, AND LIQUIDS," (a communication to me from abroad by Thomas Sutcliffe Mort and Eugene Dominique Nicolle, of Sydney, in the Colony of New South Wales,) and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement thereof, that is to say :—

The apparatus I am about to describe is an improved mechanical combination for obtaining cold by an application of the well known natural law that a reduction of the volume of any permanent gas and simultaneous removal of the sensible heat caused thereby results upon expansion in a capacity for or power of taking heat from the bodies with which it comes in contact. This fact has been for years known and published to the world, and for the purpose of utilizing it many Patents have been obtained, involving delicate machinery working at great speed, difficult to keep in working order, and losing a large per-centage of the reduced temperature during its operation, which combined reasons have caused the subsequent abandonment of most of them. The new combination avoids these difficulties, and can be worked by an ordinary engine driver. No air pump enters into the arrangement, the compression of air or other gases being effected by means of the well known hydraulic ram in large hydraulic cylinders. The regularity of speed in the machine is obtained by the variable expansion of steam in the steam cylinder meeting the actual demand of power required for the progressive compression of the gas in the upper part of the cylinders during each successive compression, the removal of the heat during the compression of the gas being effected by the spirals in the hydraulic cylinders themselves, thus simplifying the process and ensuring a perfect action. The machine uses the same gas and the same water continuously, and the gas is desiccated in its passage after compression. The temperature exchanger saves a great amount of cold, as it retains the surplus of cold left in the gas after having refrigerated to the lowest degree required, and imparts this surplus cold to the compressed gas as it passes through it on its way to the vessel where it expands, which will hereafter be fully described. The pressure, and therefore the amount of reduction of temperature necessary, is easily regulated by increasing or decreasing the quantity of water in circulation, which is effected while the machine is working and ascertained most accurately by the pressure indicator. The quantity of gas necessary to ensure the perfect working of the machine

is also self-controlling and regulated after each successive expansion. The slide valves introduced here are of a peculiar construction, which renders their equilibrium perfect, and although the pressure against them is very considerable they work with great ease. The application of refrigeration to the preservation of articles of food, the manufacture of ice, the cooling of liquids, or the lowering of the temperature of rooms, etc. by the expansion of permanent gases is simple and effective. In the case of articles of food they are placed in a thin metallic cylinder (metal being a good conductor) encircled by a cylinder of wood (a bad conductor), the metallic and the wooden cylinders being separated by a spiral or spirals made of wood of sufficient thickness to form the ribs of the two cylinders, great strength in which is ensured by bolting the two together through the wooden spirals. The gases are expanded in the space between the spirals, whereby the reduction of the temperature is accomplished, and after circulation are led back to the apparatus for recompression. The plan for the manufacture of ice is specially explained hereafter in its proper place, and to which reference is made. For the cooling of rooms, liquids, etc. a similar arrangement to that employed for preserving articles of food may be used, or they may be cooled by the expansion of the air by direct application, or in pipes or tubes passing around or through the vessels containing liquids or the apartments requiring to be cooled. The circulation of gas employed is perfect and the transmission of the reduced temperature very rapid. The articles of food, etc. to be acted upon not being exposed to the action of the gas by contact are not desiccated, but only refrigerated by metallic transmission, which does not injure them in the slightest degree.

Having thus briefly described the apparatus and of what the improvements consist, on parts of which I shall hereafter base the special claims, I shall now proceed to describe with the assistance of the accompanying Plans and Figures each of the several parts of the machine, having for that purpose drawn separately the mode of obtaining the power of compression and the modes of its application. The Drawings and sections hereto attached are given to illustrate the action of the apparatus although the forms or shapes of the several parts may be varied without interfering with its working, relative capacity and strength being provided for.

Drawing No. 1.—Figure 1, a side elevation of the engine and hydraulic rams; Figure 2, a bird's-eye view of the same; Figure 3, an

end view shewing the variable expansion gear for steam called time wheel.

Drawing No. 2.—A sectional elevation shewing the working of the apparatus.

Drawing No. 3.—Figures shewing plan of details.

Drawing No. 4 shews the direct action of a column of water as a substitute for other power for compressing air.

The mode of obtaining power here described is steam, but any other power, such as horse, mill, waterfall, with direct pressure or transmitted by turbine or water wheel, screw propelled by the motion of a sailing vessel, windmill, or hand power can be applied with good result. The form of engine and its construction, either vertical, horizontal, or oscillating, are not matters connected with the improvement. I use by preference a double cylinder engine working the hydraulic ram direct, water being the fluid used in connection with the ram, although oil or other fluids may be used. With the exception of the expansion gear and the transmission of motion to the time shaft engines of any description can be applied. I will therefore only refer to those parts.

Steam Motive Power.

Drawing No. 1.—No. 1, 1, the expansion valves to cut off steam at any part of the stroke of the engines as the power of compressing the gas requires. For reference see detailed Drawing No. 3, Figures 5 and 6.

2, 2, time wheel with cams of different sizes cutting off steam. For reference see detailed Drawing No. 3, Figure 7 and time wheel table; 3, 3, beam levers transmitting the motion of the cams to the piston of expansion valve; 4, time shaft receiving its motion from the main shaft of the engine by a worm and wheel there indicated, the number of teeth in the wheel being 24, and each revolution of the engine causing by the worm in gear the wheel to advance one tooth; 5, 5, 5, three spur wheels transmitting the motion as received from the worm without increase or decrease of speed; 6, 6, wheel and pinion serving to retard the motion received from the worm and wheel in the proportion of one to two, giving therefore 48 revolutions of the engine to one of the time shaft No. 4. The expansion cam wheel performing one complete revolution during 24 revolutions of the engine shaft; 6A, 6A, hydraulic rams connected with the piston end by cross heads;

7, 7, hydraulic barrels fitted with double leather rings and packing stuffing box, the pressure acting against the leather and the stuffing box during the partial vacuum; 8, 8, hydraulic valves (see detailed Drawing No. 3, Figures 1 and 3); 9, delivery pipe branching to each delivery valve; 10, 10, suction pipes connected with the suction valves.

This completes the motive-power apparatus shewn in Drawing No. 1.

Drawing No. 2 shows working of apparatus by steam power.

11, 11, two strong hydraulic cylinders made of wrought iron and capable of working safely at a pressure of 600 lbs. to the square inch; 12, 12, 12, are sixteen copper double spiral tubes through which a current of cold water is constantly passing. Each hydraulic cylinder is fitted with a set of sixteen of these double spirals; 13, 13, upper water compartments through which the water having refrigerated the compressed gas is allowed to escape; 14, 14, top water compartments receiving the water for refrigerating the gas; 15, 15, connecting flanges which unite the suction pipes, No. 10, 10, fixed on the suction valves of the hydraulic rams, thereby connecting the two apparatus together; 16, 16, lower hydraulic slide valves, enabling the water alternately to be pumped out of each hydraulic cylinder (this valve is constructed on the equilibrium principle, see Drawing No. 3, Figure 8, for details); 17, 17, suction pipes connecting the slide valves with the hydraulic cylinders; 18, 18, upper hydraulic slide valves also on the equilibrium principle, enabling the compressed water to escape into the hydraulic cylinders No. 11, 11; 19, 19, branch pipes connecting the valve chambers with the suction pipes; 20, 20, levers transmitting the motion of the cam to the slide rod at the end of which the slide valves are fitted; 21 strong wrought cylinder capable of working safely under a pressure of 600 lbs. to the square inch; 22, pressure indicator fitted to the iron cylinder; 23, connecting flanges uniting the branch pipes of the motive power apparatus; 24, 24, bent pipes connecting the chambers at the valve No. 18, 18; 25, 25, eight iron cam discs fitted close to each other on the time shaft No. 4, for the purpose of opening and shutting the valve at the proper time; 26, 26, double gas slide valves enabling the gas to escape into the temperature exchanger after having been compressed. For construction see detailed Drawing No. 3, Figure 9; 27, 27, connecting pipes uniting the upper part of the hydraulic cylinders with the gas valves, No. 26, 26; 28, 28, levers transmitting the motion of the cams to the slide valves 26, 26, by a vertical rod at the end of which a

gudgeon is fitted sliding in the grooves of the disc cam; 29, two gas valves for the purpose of returning the expanded gas to the hydraulic cylinders to be recompressed; 30, 30, connecting pipes uniting the hydraulic cylinders with the gas cocks 29, 29; 31, 31, sniffing valves balanced by a spiral spring to a pressure equal to that of the atmosphere. This valve opens internally; 32, 32, levers connecting the slide valve rods and transmitting the motion by a vertical rod fitted with a gudgeon sliding in the slots forming the cams; 33, slotted cam fixed on the time shaft giving the motion to the levers 32, 32, to open and close the valve at the moment required; 34, 34, connecting pipes uniting the valves 29, 29, with the casing of the temperature exchanger; 35 temperature exchanger constructed with small copper tubes 14 feet long through which the compressed gas passes. The whole internal capacity of these tubes being equal to that of the bulk of the compressed air when at its maximum pressure. They are enclosed in a circular casing through which the gas passes after having been expanded. This casing is covered externally with a non-conducting substance such as felt, charcoal, etc.; 36, 36, returning pipe connecting the outer spiral of the refrigerated chamber with the casing of the temperature exchanger, No. 35; 37, 37, gas desiccators connected between the gas cocks 26, 26, and the temperature exchanger No. 35; 38, gas valve fitted between the compressed gas chamber and the temperature exchanger No. 35; 39, connecting pipe uniting the gas valve 38 at one end, and the temperature exchanger at the other. The connection is arranged so that the compressed gas inside the tubes only can pass while the returned expanded gas circulates in the opposite direction outside the tubes; 40, compressed gas receiver made of wrought iron perfectly tight, capable of working safely at a pressure of 600 lbs. to the square inch; the internal capacity of this receiver is equal to that of the compressed gas in the hydraulic cylinders No. 11, 11. The outer surface of this apparatus, including the valves placed at each end of it, is surrounded with a non-conducting substance such as felt, charcoal, etc. and enclosed in a wooden box; 41, expansion gas valve fitted at the extreme end of the compressed gas receiver No. 40, causing the sudden expansion of the gas contained in it into the refrigerating chamber; 42, beam lever transmitting the motion given by the cam fixed on the time shaft by a vertical rod fitted with a gudgeon sliding in the slot of the cam. The arrangement is such that one valve is closed before the other opens; 43, slotted cam fixed on the time shaft No. 4, giving the motion to the valves 41 and 38 at the

necessary time hereafter described; 44, taper pipe connecting the expansion gas valve No. 41 with the refrigerating chamber.

REFRIGERATING CHAMBER.

45, single or double spiral according to the length of the cylinder, which will vary its requirements. This spiral (or spirals) is formed by bending pieces of timber 2 inches × 2 inches angularly with the cross sections of the wooden cylinder, thus forming a screw or spiral, the pitch of which should be about 12 in. apart. If the chamber be constructed very large in diameter and the length be short the spiral is continued at the flat end of the cylinders, leaving only an aperture conveniently large to store the articles of food in the chamber. In that case the expansion of the gas employed would begin near the centre of the cylinder, and having played over the whole of the end of the cylinder in a spiral gradually increasing in diameter until it reaches the outer spiral in which it enters, it continues its motion all round the cylinder until it attains its extreme end, on which a similar concentric spiral leads the gas to the centre of the cylinder where the return gas pipe No. 36 is attached, and conveys the gas to the hydraulic cylinder to be compressed again. Should the cylinder for convenience be constructed small in diameter and of long length a double spiral is employed by which the expansion of the gas alternately takes place, first at one end and next at the other, each expansion of gas having its own spiral. A perfect equalization of temperature is thus obtained. 46, a thin metallic cylinder made air tight, bolted against the ribs forming the spiral, the bolts passing through them and through the outer wooden cylinder No. 47, the head of these bolts being broad and flattened, pressing on the internal part of the metallic cylinder. 47, outer wooden cylinder made of staves grooved and tongued gas tight and strongly hooped outside. These staves are also united together by the wooden spiral ribs binding them strongly by the bolts fixed at intervals not exceeding 12 inches.

Another advantage derived by this construction is that the ribs thus bolted afford a great stiffness and protection to the internal metallic cylinder. The nuts are countersunk and a dowel of wood let in flush for the purpose of avoiding conduction by the iron bolts. 48, envelope made of tarred felt or other suitable substance fastened to the outer surface of the wooden cylinder as protection against damp, and also

answering as a non-conducting substance; 49, water pipe and stop cock fitted at the back of the valve chamber No. 16; 50, water tank used as tender when required.

Having described the various parts generally and in detail, it now remains to explain the practical operation thereof which is commenced by charging the vessels by a force pump (or by the hydraulic ram attached to the engine). First, the middle cylinder with air or whatever gas may be used, then pumping water into it until the pressure indicator marks 300 lbs. per square inch more or less according to the intensity of cold required. Air is introduced into the hydraulic cylinders No. 11, 11, at the atmospheric pressure, and the expansion valve No. 41 being closed (having been disconnected from the beam lever, each valve can be worked independently), 38 is opened, and both 26, 26, closed, and finally both 29, 29, closed. Water is then pumped into the right hand cylinder No. 11 until the air above it is compressed to 300 lbs. per square inch or is condensed to a volume $\frac{1}{20}$th of its original bulk as shewn in the plan by the blue line and marked "compressed air." The gas valve 26 (right hand) being acted upon by hand opens slightly and lets the compressed air leak out into the desiccator 37. The water being still forced into the hydraulic cylinder maintaining the pressure of 300 lbs. until it has reached the top of the cylinder. The air having been desiccated by passing through the desiccator 37 containing chloride of calcium in powder, or semi-liquid or potassa in the same state, or any other substance having affinity for moisture, passes into the tube of the temperature exchanger, the gas valve 26 (right hand) being closed, and 38 being opened, the air passes into the air receiver 40, and 29 (right hand) being opened the stop cock attached to the pipe 49 is opened, and the water escapes into the water tank. The sniffing valve 31 is caused to open as water flows out of the cylinder until the full quantity of air required to fill the cylinder is supplied. Water is again pumped in as before, and when the pressure of 300 lbs. has been obtained, the valve 26 is opened in a similar manner as before described. This operation is repeated until a pressure of air equal to 300 lbs. is obtained, the last charge of water is left in the right-hand cylinder, and a charge of air at the atmospheric pressure is introduced into the left-hand cylinder. All the connections being then made perfect, the steam expansion cams being set at the first tooth (which gives the greatest amount of expansion to the steam) the engine, and with it the hydraulic rams, are set in motion and the following

effect takes place :—The expansion air valve 41 being at the time open, and consequently 38 closed, the volume of air enclosed in the receiver 40 under a pressure of 300 lbs. per square inch is suddenly expanded passing during its expansion by the pipe 44, and circulating in the spirals of the refrigerating chamber 45, returning by the pipe 36, 36. The expanded air in travelling round the metallic cylinder abstracts from it the heat it contains, and the air returns with the heat thus taken up. The expansion of air being completed the cam fixed on the time shaft 4 closes the valve 41 and opens 38. The cam 25 now causes the water valve 16 (left hand) to open, and the quantity of water left in the hydraulic cylinder (left hand) as indicated by the blue line is immediately pumped into the middle hydraulic cylinder. The valve 26 (right hand) being acted upon by the cam fixed on the time shaft 4 lets the compressed air pass through the desiccator 37, and restores the former pressure in the expanding air receiver, 26 (right hand) closes, after which the returning gas valve 29 opens, and the expanded air rushes into the empty hydraulic cylinder 11 (left hand), and should any quantity of air be lost during its compression or expansion the sniffing valve is opened by the atmospheric pressure from without, and supplies the cylinder with the proper quantity of air before compression takes place. The air in returning passes by the temperature exchanger outside the tubes, and the surplus of cold it contains is transmitted through the copper pipes to the compressed air therein enclosed. This constant surplus being given to the apparatus soon reduces its temperature, and the compressed air begins its expansion at a reduction in temperature which goes on accumulating until it reaches its working maximum. This arrangement saves a large amount of cold which otherwise would be lost. The returning gas valve 29 (left hand) closes, after which the water valve 16 (left hand) closes, and the top valve 18 opens, by the same motion letting the compressed water out of the middle cylinder rush into the hydraulic cylinder 11 (left hand). The air enclosed in the hydraulic cylinder is immediately compressed and the heat generated by compression is removed by the current of cold water passing through the copper spiral tubes. The valve 15 (right hand) opens by the motion of the cam fixed on the time shaft 4, and closes the upper valve 18 (right hand). The water under pressure in the hydraulic cylinder No. 11 (right hand) is in the first instance forced against the hydraulic rams, propelling them and filling the barrels at the same time, and by the return motion of the ram the water is forced into the middle

cylinder, thus restoring the maximum pressure therein, at the same time completing the pressure of air in the hydraulic cylinder 11 (left hand) until the whole of the water in the hydraulic cylinder 11 (right hand) is pumped out. When the water forced by the increasing pressure in the middle cylinder caused by the working of the ram emptying the hydraulic cylinder 11 (right hand) has arrived at the height marked "compressed air" the gas valve 26 opens gently, and lets the compressed air leak out through the desiccator, and entering into the temperature exchanger and the compressed gas receiver 40 the full pressure is again restored there, and the hydraulic rams still working maintain the normal pressure. The hydraulic cylinder 11 (right hand) being empty, and the compressed air forced out of it by the water, the gas valve 26 (left hand) closes, and the same action is repeated in the same order with the other hydraulic cylinder, and so on alternately so long as the engine is in motion. The air is successively expanded from the gas receiver into the refrigerating spirals round the refrigerated cylinder, and gives four expansions of air per minute, the engine giving ninety-six revolutions in the same time. The chloride of calcium or whatever substance is used for desiccating the air is changed every day if required, the moisture is driven off by heat and the same substance may be used over and over again. Should the machine be required to be worked at a greater reduction of temperature the stop-cock attached to the pipe 49 is opened during the suction of the hydraulic ram. More water is then introduced into the apparatus, and immediately a greater pressure is obtained, producing a greater reduction of temperature, but at the same time the pressure of steam must be increased to meet the extra work. The same appliance is used to replace the loss of water caused by evaporation or leakage. As will be seen the foregoing description shows how the apparatus is set in motion by power derived from a steam engine, water wheel, screw propeller, etc.

Drawing No. 4 shews the apparatus working by a column of water of any given height acting directly upon the air in the cylinders and exerting a pressure of 15 lbs. per square inch for every 32 feet of that vertical column of water. The valves for the distribution of air and water are set in motion by a small hydraulic turbine of about half horse power, acting upon the time shaft No. 4, by a worm and wheel and driving the cams in a similar order as before described. The speed of the apparatus is regulated by a conical pendulum and throttle valve some-

what similar to that of a steam engine. The time shaft may be acted upon by a water engine, water wheel, either undershot or overshot, or by a waterfall. The application of the reduction of temperature here indicated is that for the conversion of water into ice by the direct contact of the refrigerated air passing through a solution of common salt, chloride of calcium, or any other liquid not congealing, excepting at a considerably lower temperature than that at which pure water is congealed. The reduction of the temperature of wort, must, or any other fluids may be effected in the same manner, or, if the direct contact with air be detrimental to the fluid to be refrigerated, a surface condenser is used. The motive power obtained from the column of water may of course be applied to the arrangement shewn in connection with the steam power for the preservation of articles of food, cooling of rooms, etc. The following details relating to the Drawing No. 4 complete the description of that plan; No. 50A, stand pipe or water column of any given height; 51, 51, branch pipe leading the water which is under the pressure of the column of water to the introduction valves 18, 18; 52, small branch pipe attached to the stand pipe 50, and connected with a small turbine water engine, water wheel, or waterfall; 53, stop-cock, serving to stop and start the turbine; 54, conical pendulum regulator connected with the throttle valve fixed on the turbine; 55, small hydraulic turbine receiving the water (under pressure) through the pipe 52; 56, horizontal shaft receiving a rotatory motion from the vertical shaft of the turbine by a pair of conical tooth wheels; 57 and 57 worm and wheel transmitting the rotatory motion of the turbine to the time shaft No. 4 in the proportion of 300 revolutions of the turbine to 48 of the cam or any increase or decrease of speed according to the amount of water at command; 58, branch pipe having a T piece in the middle discharging the waste water leading from the pipe 15, 15, which connects the two delivery valves 16, 16; 44, pipe leading the expanding air into the freezing apparatus; 59, air rose, for the delivery of expanding air into the freezing medium. This rose is perforated with minute holes and placed angularly near to the bottom of the freezing apparatus so as to cause a rotatory motion to the liquid therein, thereby obtaining a perfect circulation outside the ice moulds and a continuous contact of the liquid in circulation with the expanding air; 60, a wooden watertight tank, by preference square, containing the freezing medium, and the tin moulds filled with water; 61, tin moulds containing the water to be frozen, which are supported on a revolving stand; 62, revolving

stand, moving on a pivot at the bottom, the shaft passing through an air-tight stuffing box at the top, provided externally with a crosshead enabling the stand to be moved without opening the door of the tank. This stand is made of wrought iron strongly built so as to carry a large quantity of water moulds of different size and shape as required; 63, level of the freezing medium composed of chloride of calcium, common salt, or any fluid congealing at a lower temperature than pure water; 64, door, made sufficiently large to introduce the moulds before freezing, and to remove them after being frozen. This door requires to be fitted air-tight; 65, air space above the freezing medium; 66, air holes through which the expanded air escapes to the temperature exchanger, No. 35; 67, upright tube fitted with stuffing box and flange connected with the air pipe, No. 36. The mode of setting the machine into action is much more simple than that used in steam power as it only requires to open the stop-cock, No. 53, which sets the turbine in motion, causing the worm and wheel 57, 57, to revolve, and to give the time shaft its motion, which by the series of cams attached opens and shuts the valves in the same order as by the motion of the steam engine in the first instance. I would remark that in this apparatus instead of the spiral condensers 12, 12, 12, being employed, the pipes 17, 17, may have a smaller pipe let in on their upper part which is carried to the top of the cylinder, the end of the pipe being returned downwards and fitted with a fine rose, from which the water descends as in a shower bath. This shower or spray of water coming into direct continuous contact with the air under compression by passing through it accepts the heat as it is generated, which is of course carried away with the water after each compression. The refrigerated air is blown into the freezing medium causing a rotatory motion of that liquid, which transmits an equal temperature throughout that fluid, causing the water exposed in the moulds to congeal. The frozen water is then removed, and the empty moulds are replenished with pure water. The same saving of the surplus of cold is effected in the same manner as before described.

Arrangement of Motive Power for Sailing Ships.

Figure 10 in Drawing No. 3 represents a bird's-eye view of the apparatus as applied to a ship. One or two small screw propellers are fitted at the stern or any other suitable part of the vessel, they are fitted with ordinary stuffing boxes. Upon each screw shaft is fitted one

eccentric or crank giving the motion to two small hydraulic rams connected by links to the eccentrics or cranks. The barrels of the hydraulic rams are united together if necessary or used singly according to the place where they are to be fixed. At the extreme ends of the screw shafts a pinion to each is fitted working into a large cog wheel retarding the motion of the time shaft 4 on which the cams necessary for working the valves are fixed. The remaining parts of the apparatus are constructed and worked in a similar manner to that before described in connection with the other motive powers. This apparatus can be constructed of any required power by increasing or decreasing the diameter of the screws and regulating the size of the hydraulic rams and apparatus accordingly. The water necessary for refrigerating the air during its compression is pumped up to the receiver attached at the top of the hydraulic cylinders from the side of the ship if required by an ordinary pump fitted with an eccentric on to the time shaft. The motion of the ship caused by the wind acting upon the sails transmits to the screw propellers a rotatory motion which sets the whole of the machine into operation, not requiring any labor and only an occasional inspection. The resistance caused by the motion of the screw propellers is not appreciable, as the machine being constantly working its size is on that account required to be very small. The ship can be cooled by distributing the compressed air when necessary either by a blast or through pipes or tubes or an air tight metallic casing fitted against the under part of the decks or rooms requiring to be cooled. Provisions can be kept in a cylinder or refrigerating chamber and ice made for the use of the passengers under the plans herein-before described. A small steam engine may be added to the present arrangement for working the apparatus while the ship is in port or becalmed.

Specification of details for construction not specially described herein shown on Drawing No. 3.

Figure 1.—A, metallic ram; D, double ring, leather between which the pressure of the fluid is allowed a free access, closing hermetically the hydraulic ram and thereby preventing the fluid from escaping; E vulcanized india-rubber and canvas elastic packing, ensuring a good vacuum during the pumping action of the ram. Figure 5 represents the steam expansion valve, K is a metallic piston fitted with an expanding metallic ring. The junk ring is perforated with six apertures allowing

a free passage of steam through the piston, which being placed between the two equal pressures renders its equilibrium perfect, requiring on that account only a small amount of power to move the piston; L, L, short cylinder in which the piston K works with a slight friction; P, P, a slot extending all round the circumference of the barrel L, L, leading into a belt which conveys the steam to the engine cylinder. The top and bottom parts of the barrel in the slot are united at six equal intervals by a small vertical piece of metal cast, in which guides the packing ring during its motion in the barrel. The total area of the slot is equal to that of the steam port. The slot is about $\frac{1}{4}$ inch wide and about $7\frac{1}{4}$ diameter. By this arrangement a very small amount of motion is required from the cams, and smooth and regular action is obtained; Figure 7 is the time wheel on which small cams are cut out and regulates the time as well as the quantity of steam required for pressing the air. The time table and diagram here delineated fully illustrate the mode of construction. Figure 8 is an equilibrium hydraulic double valve. The slide valves are both connected and moved by a thumb joint in the middle; each slide valve is connected by link to an elastic diaphragm H, H, which is made of a flexible metallic disc fixed between two discs of leather or other elastic substance and screwed together air-tight. The surface of the disc is made one-eighth part less area than the valve, so that $\frac{7}{8}$ths of the direct pressure against the valve are removed, enabling the valve to work with great ease.

Figure 9, details of double air valve. This valve is so constructed that when the pressure changes from right to left the valve still intercepts any passage of compressed air. The ports are made by preference circular, although any other form would answer. The double wrought-iron studs on which the valves are fitted are lined with a vulcanized india-rubber disc keeping a gentle pressure against the face of the valves in order to allow the pressure to open the valve from its face and when required to fill the small chamber, after which the pressure exerts its full energy to keep the other valve close, and vice versâ. A vertical rod G moves the two valves through a stuffing box at the time required by the cams.

Having now described the nature and object of the Invention, of which I claim the general combination for its especial novelty, being an improved method of and apparatus for obtaining reduction of temperature by the expansion of air or other permanent gases in special connection

with the preservation of articles of food, the manufacture of ice, and cooling of rooms and liquids, I specially and separately claim,—

First. The combination of time wheel producing the variable expansion of steam as the work of compressing air requires, which differs at every stroke of the hydraulic ram during the compression of one hydraulic cylinder (as per time table).

Second. The construction of the expansion valve as shown in the detail Drawing.

Third. The peculiar construction of the equilibrium hydraulic valves and their general arrangement.

Fourth. The peculiar arrangement and construction of the hydraulic rams.

Fifth. The peculiar construction of the double air slide valves and their arrangement.

Sixth. The arrangement and combination of sniffing valve to supply the deficiency of air when required.

Seventh. The arrangement and combination of the water tender attached to the suction valve introduced to restore the proper amount of water in the apparatus when working by intermediate motive power.

Eighth. The mode of refrigerating the compressed air by copper spirals not passing through the cylinder.

Ninth. The combination and arrangement of the temperature exchanger.

Tenth. The combination and arrangement of the expansion valve connected with the intercepting valve 38.

Eleventh. The combination and peculiar construction of the refrigerating chamber.

Twelfth. The arrangement and combination of the direct action by a column of water.

Thirteenth. The mode of applying the refrigerated air to the apparatus herein described for the congelation of water, cooling of liquids, rooms, &c.

Fourteenth. The arrangement and combination of the cams distributing the motion of the valves throughout the apparatus.

Fifteenth. The combination of the turbine or other water power to regulate the working of the apparatus.

Sixteenth. I claim the combination of screw propellers fitted to sailing ships in the manner herein described for obtaining a motive power by the motion of the sailing ship, enabling me by its application to the apparatus to preserve articles of food, to make ice, to cool liquids, and to ventilate and cool ships and rooms.

In witness whereof, I, the said William Mort, have hereunto set my hand and seal, this Seventeenth day of October, in the year of our Lord One thousand eight hundred and sixty-eight.

WILLIAM MORT. (L.S.)

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